Section 6
6. Summary and Conclusions

This section summarizes the results of this SLAD. It highlights results from the data flow analysis as well as results from the analysis scenarios. Lastly, it emphasizes significant findings from this analysis.

6.1 Data Flow Analysis Summary

Twelve categories of data flows were identified to transverse the ETMS FIRMNet network. Of the 12 data flows, seven are downlink data flows, three are uplink data flows, and two flow in both directions. Overall, traffic flows from VNTSC to the TMUs (downlink traffic) create a greater amount of load on the system than the traffic flowing to VNTSC (uplink traffic). Additionally, Flight Data Distribution, Weather Data, Monitor Alert Data, and ADL Distribution constitute more than 90 percent of the total ETMS data flow.

Flight Data Distribution is composed of numerous flight messages batched together into a single packet. These packets are sent from VNTSC to the TMUs once the packet size reaches 7.7KB or 5 seconds have passed. Weather Data is composed of multiple files and are sent from VNTSC to the TMUs at fixed timed intervals. The size of these files varies based on the present weather conditions. During the time of this analysis, large weather files were unavailable. Monitor Alert Data, which averages 173 KB, is sent from VNTSC to the TMUs every minute. ADL Distribution, which averages 50KB, is also sent from VNTSC to the TMUs.

6.2 SLAD Summary

Table 6-1 summarizes and captures the SLAD results for the baseline scenario and the three analysis scenarios.

Table 6-1: Summary of Analysis Results

	Description	Average TMU Downlink Percentage Increase	Average TMU Uplink Percentage Increase	Average Backbone Utilization
Baseline	Typical day with normal air traffic and weather conditions	N/A	N/A	19%
Scenario 2a	Increased frequency of Monitor Alert Data Flow	33%	N/A	24%
Scenario 2b	Projected air traffic increase throughout US	*5 years:* 12.5% *10 years: 25%*	*5 years:* 5% *10 years:* 10%	*5 years:* 20% *10 years:* 22%
Scenario 2c	Regional projected air traffic increase	*5 years:* 15% *10 years:* 31%	*5 years: 14%* *10 years:* 33%	*5 years:* 21% *10 years:* 24%

Scenario 2a indicates that adding large data files to the network at a high frequency (every 30 seconds) will impact system performance. When the frequency for the Monitor Alert Data flow is doubled, the average backbone utilization across the network increases from 19 to 24 percent. Because Monitor Alert is a downlink data flow, on average, each TMU will experience a 33 percent increase of incoming traffic as a result of this scenario. Additionally, there is a 27 percent increase in the total traffic leaving VNTSC to the TMUs.

Scenario 2b projects an increase of 25 percent over the next 10 years in air traffic operations data. This growth projection will increase the traffic going into and out of VNTSC by more than 20 percent. There is only a minimal effect to the overall network utilization with an increase of less than 10 percent in 10 years. As previously mentioned, Flight Data Distribution and ADL Distribution are two of the four major data flows and they are affected by changes in air traffic operations. Thus, the percentage increase in traffic entering TMUs is much greater than the percentage increase in traffic leaving the TMUs. Specifically, with a 2.25 percent increase in air traffic per year for 10 years, downlink traffic increases by approximately 25 percent compared to an uplink traffic increase of 10 percent after 10 years.

Scenario 2c indicates an increase in air traffic operations data, based on regional growth. This scenario has similar results to Scenario 2b in which the traffic is increased uniformly across the network. This is because all TMUs receive the same flight data regardless of location. Although uplink traffic is a small part of the total traffic, there is a noticeable difference in uplink data traffic coming from the ARTCCs based on the regional growth. This information provides growth projections for link utilization if other network architectures, such as a distributed network, are considered. The large difference in uplink traffic, as a result of regional growth, is apparent in Table 6-1. Specifically, the model results reveal that uplink traffic from TMUs increases by an average of 33 percent after 10 years as compared to 10 percent in Scenario 2b.

Finally, results indicate that the FIRMNet backbone is well capacitated to handle the traffic increases experienced in all scenarios. With an increase in airline flight traffic over the next 10 years, the backbone network should be able to handle the demand but delays and congestion will be noticed over highly utilized links. The two most utilized links in all scenarios were VNTSC to ZNY, and ZNY to ZDC, and they are identified as potential bottlenecks in the system. Scenario 2a caused the most congestion on the network in which the VNTSC to ZNY, and ZNY to ZDC links were 60 percent and 61 percent utilized, respectively. Consequently, future system architecture changes and designs should consider enhancements to these two links, particularly during the convection weather season in the summer.